

What is claimed is:

1. A device for managing respiration of a patient comprising:

5 at least one electrode configured to be coupled to tissue of a patient's body wherein the at least one electrode is configured to deliver electrical stimulation to the tissue to thereby elicit a diaphragm respiratory response;

10 a sensor configured to sense information corresponding to the patient's respiration; and

15 a responsive device coupled to the at least one electrode, the responsive device being configured to respond to information sensed by the sensor by controlling electrical stimulation delivered to the tissue through the at least one electrode.

2. The device of claim 1 wherein the sensor comprises the at least one electrode.

20 3. The device of claim 1 wherein the sensor is configured to sense and determine information corresponding to a patient's respiration.

25 4. The device of claim 1 wherein the sensor is configured to sense and the responsive device is configured to determine information corresponding to a patient's respiratory rate.

30 5. The device of claim 1 wherein the sensor is configured to sense and the responsive device is configured to determine information corresponding to a patient's inspiration rate.

6. The device of claim 1 wherein the sensor is configured to sense and the responsive device is configured to determine information corresponding to a patient's

5 exhalation rate.

7. The device of claim 1 wherein the sensor is an EMG electrode configured to sense a diaphragm EMG.

10 8. The device of claim 1 wherein the sensor is an electrode configured to sense phrenic nerve activity.

9. The device of claim 1 wherein the sensor is a movement detector.

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10. The device of claim 9 wherein the sensor is configured to sense movement of a diaphragm of a patient in whom it implanted.

20 11. The device of claim 1 wherein the responsive device further comprises an apnea detector coupled to the sensor.

12. The device of claim 11 wherein the apnea detector is configured to detect the absence of effective phrenic nerve 25 activity.

13. The device of claim 11 wherein the apnea detector is configured to detect the absence of effective diaphragm EMG.

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14. The device of claim 11 wherein the apnea detector is configured to detect an attenuated phrenic nerve signal below a preset value.

5 15. The device of claim 11 wherein the apnea detector is configured to detect an attenuated EMG below a preset value.

10 16. The device of claim 11 wherein the responsive device is configured to deliver electrical stimulation to the at least one electrode in response to detecting apnea.

15 17. The device of claim 1 wherein the responsive device further comprising a hypoventilation detector coupled to the sensor.

18. The device of claim 17 wherein the responsive device is configured to deliver electrical stimulation to the at least one electrode in response to detecting hypoventilation.

20 19. The device of claim 1 further comprising a hyperventilation detector coupled to the sensor.

25 20. The device of claim 1 wherein the responsive device is configured to adjust stimulation delivered through the at least one electrode based upon information sensed by the sensor.

30 21. The device of claim 20 wherein the responsive device is configured to compare the sensed information to a

predetermined value and to adjust the stimulation output to elicit sensed information matching the predetermined value.

22. The device of claim 1 wherein the responsive device  
5 further comprises a processor and a telemetry device, and  
wherein the responsive device is implantable within the  
patient.

23. The device of claim 22 wherein the responsive device  
10 is configured to receive and store programming information  
from an external device through the telemetry device.

24. The device of claim 22 wherein the responsive device  
is configured to send event information corresponding to  
15 information sensed by the sensor to an external device  
through the telemetry device.

25. The device of claim 22 further comprising an external  
device configured to telemetrically communicate with the  
20 responsive device.

26. The device of claim 25 wherein the external device  
further comprises a user interface for receiving data from  
the patient.

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27. The device of claim 25 wherein the external device  
further comprises a communication interface configured to  
communicate with a provider.

30 28. The device of claim 1 further comprising a position  
sensor coupled to the responsive device and configured to

sense a relative position of a patient and to deliver a corresponding signal to the responsive device.

29. The device of claim 1 further comprising an  
5 accelerometer coupled to the responsive device and configured to sense a relative motion of a patient and to deliver a corresponding signal to the responsive device.

30. A device for managing treatment of a patient  
10 comprising:

an implantable sensor configured to sense information corresponding to the patient's respiration;

an implantable memory device coupled to the sensor configured to store the information sensed; and

15 a telemetry device coupled to the memory device configured to communicate the information stored in the memory to an external device.

31. The device of claim 30 wherein the sensor comprises at  
20 least one electrode.

32. The device of claim 31 wherein the sensor is configured to sense an EMG of a diaphragm.

25 33. The device of claim 31 wherein the sensor is configured to sense phrenic nerve activity.

34. The device of claim 30 further comprising a processor  
coupled to the memory device and to the sensor, wherein the  
30 processor is configured to detect occurrence of a respiratory event.

35. The device of claim 34 wherein the respiratory event is apnea.

36. The device of claim 35 wherein the event is complete  
5 apnea.

37. The device of claim 35 wherein the event is partial apnea.

10 38. The device of claim 34 wherein the respiratory event is hypoventilation.

39. The device of claim 34 wherein the respiratory event is hyperventilation.

15 40. The device of claim 39 further comprising an external device, wherein the external device is configured to communicate to the patient to comply with medication requirements in response to detecting the occurrence of  
20 hyperventilation.

41. The device of claim 39 further comprising an external device, wherein the external device is configured to prompt the patient to communicate with a health care provide upon  
25 occurrence of hyperventilation.

42. The device of claim 39 further comprising an activity level sensor, wherein the processor is configured to compare a respiratory rate with an expected respiratory  
30 rate for a sensed activity level to determine an if hyperventilation has occurred.

43. The device of claim 30 further comprising an external device configured to upload information from the memory device.

5 44. The device of claim 43 wherein the external device is configured to track patient activity compliance.

10 45. The device of claim 44 wherein the external device includes a patient interface configured to receive patient input concerning patient activity compliance.

46. The device of claim 45 wherein activity compliance comprises drug treatment compliance.

15 47. The device of claim 43 wherein the external device is configured to recommend patient activity based on information uploaded from the memory device.

20 48. The device of claim 47 wherein the recommended patient activity is a recommended drug regimen.

49. The device of claim 43 wherein the external device comprises a communication device configured to communicate uploaded information to a health care provider.

25 50. The device of claim 49 wherein the communication device is configured to communicate patient activity compliance information to a health care provider.

30 51. A device for managing respiration of a patient comprising:

at least one electrode configured to be coupled to tissue of a patient's body wherein the at least one electrode is configured to deliver electrical stimulation to the tissue to thereby elicit a diaphragm respiratory response;

5 a sensor configured to sense information corresponding to the patient's respiration, wherein said sensor is configured to sense respiratory response; and

10 a programming device configured to adjust stimulation parameters to elicit a desired respiratory response.

52. The device of claim 51 wherein said electrical stimulation comprises a burst of pulses and wherein the programming device is configured to adjust amplitude of the 15 pulses.

53. The device of claim 51 wherein said electrical stimulation comprises a burst of pulses and wherein the programming device is configured to adjust frequency of the 20 pulses.

54. The device of claim 51 wherein said electrical stimulation comprises a burst of pulses and wherein the programming device is configured to adjust pulse width of 25 the pulses.

55. The device of claim 51 wherein said electrical stimulation comprises a burst of pulses and wherein the programming device is configured to adjust duration of the 30 pulses.

56. The device of claim 51 wherein the programming device is configured to adjust stimulation to control tidal volume of a respiratory cycle.

5 57. The device of claim 51 wherein the programming device is configured to adjust stimulation to control inspiration rate.

10 58. The device of claim 51 wherein the programming device is configured to adjust stimulation to control exhalation rate.

59. A device for managing respiration of a patient comprising:

15 an electrical stimulation means for stimulating tissue of a patient to elicit a diaphragm response;  
a sensing means for sensing information corresponding to the patient's respiration; and  
a responsive means for responding to information  
20 sensed by the sensing means by controlling electrical stimulation delivered to the tissue through electrical stimulation means.

60. A device for managing treatment of a patient comprising:

25 a sensing means for sensing information corresponding to the patient's respiration;  
a processing means for determining a respiratory event from the sensed information;  
30 a memory means for storing the information sensed, the memory means being coupled to the sensing means; and

a telemetry means for communicating the information stored in the memory means to an external means for receiving information, the telemetry means being coupled to the memory means.

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61. A method of controlling the respiration of a patient comprising the steps of:

sensing information corresponding to the respiration of the patient; and

10 determining whether to electrically stimulate the tissue to elicit a diaphragm response in the patient.

62. The method of claim 61 wherein the step of sensing information comprises sensing the EMG of a diaphragm of the 15 patient.

63. The method of claim 61 wherein the step of sensing information comprises sensing phrenic nerve activity of the patient.

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64. The method of claim 61 wherein the step of determining whether to electrically stimulate comprises detecting apnea; and

25 further comprising the step of electrically stimulating the tissue to elicit diaphragm movement in response to detecting apnea.

65. The method of claim 64 further comprising the step of sensing respiratory response to electrically stimulating 30 the tissue and adjusting stimulation parameters to elicit an adjusted response to further electrical stimulation.

66. The method of claim 64 further comprising the steps of sensing resumption of intrinsic breathing in a patient after electrically stimulating the tissue to elicit the diaphragm response; and ceasing electrical stimulation

5 after sensing resumption of intrinsic breathing.

67. The method of claim 64 further comprising the step of sensing hyperventilation prior to sensing apnea.

10 68. The method of claim 61 wherein the step of determining whether to electrically stimulate comprises detecting hypoventilation; and

15 further comprising the step of electrically stimulating the tissue to increase the diaphragm response.

15 69. The method of claim 68 further comprising the steps of sensing diaphragm response to electrically stimulating the tissue and adjusting stimulation parameters to cause an adjusted response to further electrical stimulation.

20 70. The method of claim 68 further comprising the steps of sensing resumption of intrinsic breathing in a patient after electrically stimulating the tissue to increase diaphragm response; and ceasing electrical stimulation

25 after sensing resumption of intrinsic breathing.

71. A method of controlling the respiration of a patient comprising the steps of:

30 sensing information corresponding to a characteristic of a patient's respiration;

comparing the characteristic to a desired characteristic; and

electrically stimulating tissue of a patient to alter the patient's respiration to cause the characteristic to approach the desired characteristic.

5 72. The method of claim 71 wherein the characteristic comprises respiration rate.

73. The method of claim 71 wherein the characteristic comprises inspiration rate.

10 74. The method of claim 71 wherein the characteristic comprises exhalation rate.

75. A method for managing the treatment of a patient  
15 comprising the steps of:

a sensing information corresponding to the patient's respiration with an implanted sensor;

storing the information sensed in an implanted memory device coupled to the sensor; and

20 communicating the information stored in the memory device to an external device for receiving information, with a telemetry device coupled to the memory device.

76. The method of claim 75 further comprising the step of  
25 communicating information received by the external device from the memory device to a health care provider through a remote interface.

77. The method of claim 75 further comprising the step of  
30 communicating information received by the external device from the memory device to the patient.

78. The method of claim 75 further comprising the step of detecting a respiratory event from the sensed information.

79. The method of claim 78 wherein the step of detecting  
5 the respiratory event comprises detecting apnea.

80. The method of claim 78 wherein the step of detecting the respiratory event comprises detecting hypoventilation.

10 81. The method of claim 78 wherein the step of detecting the respiratory event comprises detecting hyperventilation.

82. The method of claim 81 further comprising the step of determining a drug regimen based after detecting  
15 hyperventilation.

83. The method of claim 81 further comprising the step of notifying the patient after detecting hyperventilation.

20 84. The method of claim 81 further comprising the step of prompting the patient to notify a health care provider after detecting hyperventilation.

85. The method of claim 81 further comprising the step of  
25 notifying a health care provider after detecting hyperventilation.

86. The method of claim 78 wherein the step of detecting the respiratory event comprises tallying the event.

30 87. The method of claim 78 wherein the step of detecting the respiratory event comprises storing information in the

memory concerning respiration of a patient occurring before the respiratory event.

88. The method of claim 78 wherein the step of detecting 5 the respiratory event comprises storing information in the memory concerning respiration of a patient occurring after the respiratory event.

89. The method of claim 78 further comprising the step of 10 receiving patient compliance information from the patient into a external memory of the external device.

90. The method of claim 89 wherein the step of receiving 15 patient compliance information comprises receiving drug treatment compliance information.

91. The method of claim 89 further comprising the step of communicating uploaded information and patient compliance information to a health care provider through a remote 20 interface.

92. A method for managing respiration of a patient comprising the steps of:

25 providing at least one electrode coupled to tissue of a patient's body whereby electrical stimulation to the tissue elicits a diaphragm respiratory response;

provide stimulation to the tissue;

sensing respiratory response to adjust parameters of the stimulation to elicit a desired respiratory response.

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93. The method of claim 92 wherein the stimulation comprises a burst of pulses and further comprising the step

of adjust amplitude of the pulses to elicit the desired response.

94. The method of claim 92 wherein the stimulation  
5 comprises a burst of pulses and further comprising the step  
of adjust frequency of the pulses to elicit the desired  
response.

95. The method of claim 92 wherein the stimulation  
10 comprises a burst of pulses and further comprising the step  
of adjust pulse width of the pulses to elicit the desired  
response.

96. The method of claim 92 wherein the stimulation  
15 comprises a burst of pulses and further comprising the step  
of adjusting duration of the pulses to elicit the desired  
result.

97. The method of claim 92 further comprising the step of  
20 adjusting stimulation to control tidal volume of a  
respiratory cycle.

98. The method of claim 92 further comprising the step of  
adjusting stimulation to control inspiration rate.

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99. The method of claim 92 further comprising the step of  
adjusting stimulation to control exhalation rate.

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